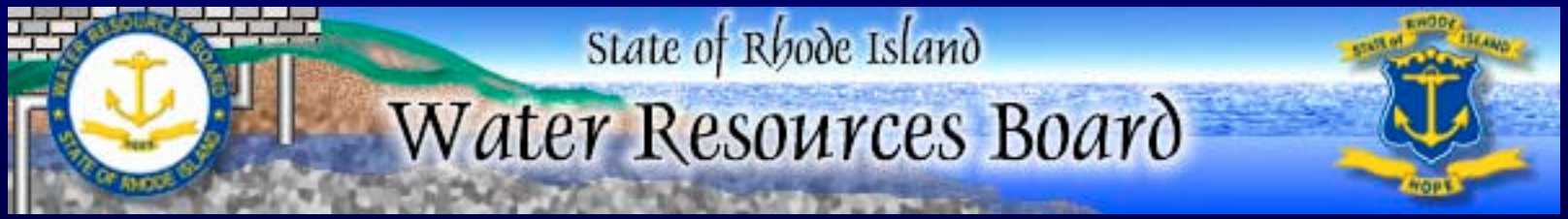
U.S. Geological Survey Rhode Island Subdistrict Program with the Rhode Island Water Resources Board

September 26, 2002



Overview

- Water Use Program
  - Water Use and Availability
  - NEWUDS Database
- Modeling
  - Ground water (HAP/Big)
  - Surface water (Usquepaug-Queen)
  - Hydrologic system – linking ground water and surface water (Pawcatuck)
- Hydrology Concepts

Water Use and Availability

Development of Water Use Program in Rhode Island

- Legislative Authority

§46-15.7-1 (b) (4)

The water resources board is the State agency which manages the withdrawal and use of the waters of the State of Rhode Island.

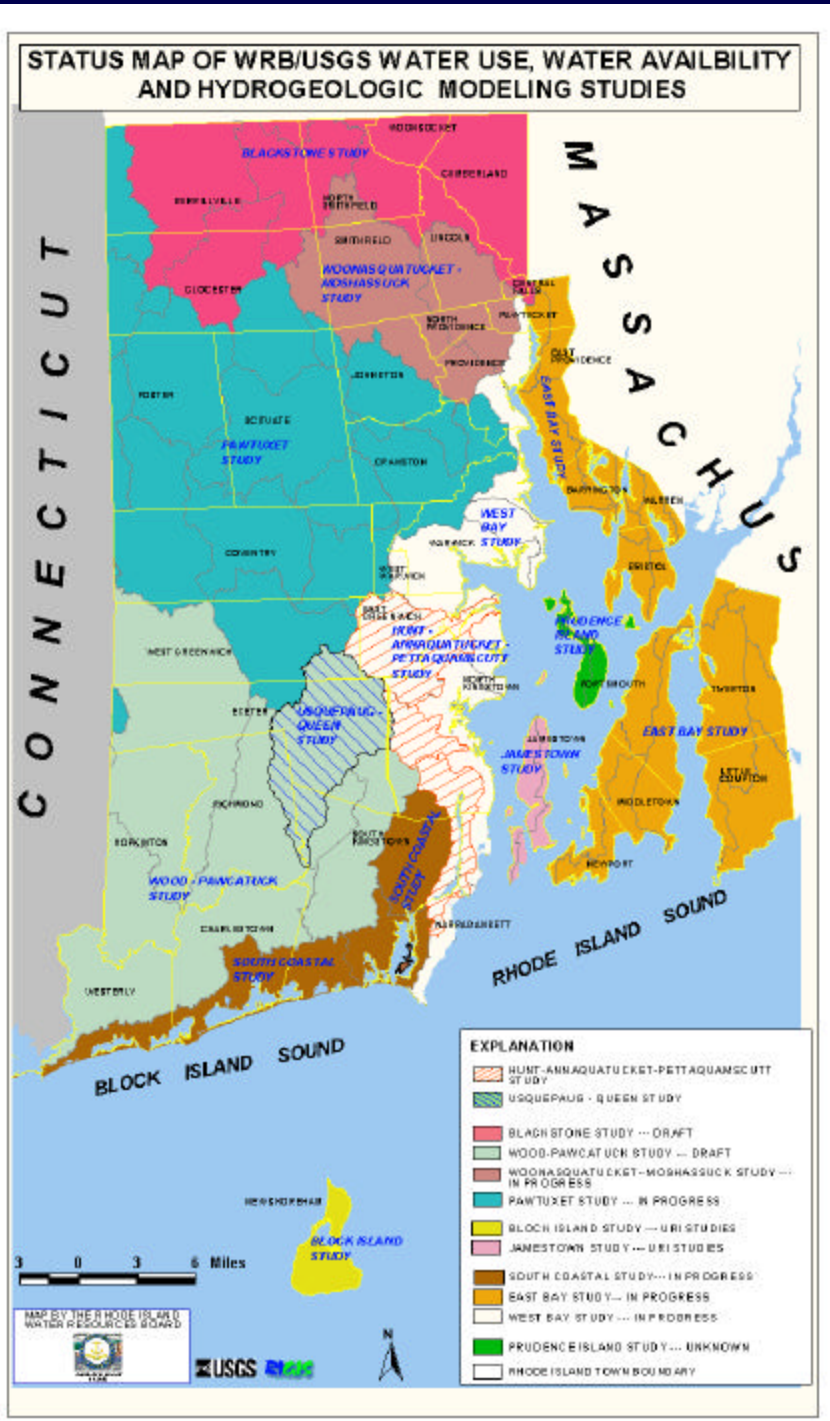
- Inventory of water resources

The purpose of this inventory shall be to establish the quantity of water existing in every water source, the water that is being used or is needed for every significant purpose, as listed in §46-15.7-1(a)(2) preceding, and the quantity that is available to support other uses.

USGS
science for a changing world

Basin Projects in Rhode Island

State of Rhode Island
Water Resources Board



Basin Water Use Projects

- Pawcatuck River Basin
- Blackstone River Basin
- Pawtuxet and Quinebaug River Basins
- Woonasquatucket and Moshassuck River Basins
- Narragansett East Bay Drainage Basin (7-02)
- South Coastal Drainage Basin (07-02)
- Narragansett West Bay Drainage Basin (9-02)
- Summary Report (7-03)

OBJECTIVES

- Populate the NEWUDS database with existing and estimated water-use data (1995-99)
- Determine water availability during an average period of no recharge (June, July, August, and September)
- Develop a water budget based on current water demands

NEWUDS Database

- Catalogs the movement of water

- Water use can be assessed within a:
  - System (potable or wastewater)
  - Town (political boundaries)
  - Basin (resource boundaries)

NEWUDS DATABASE – WATER USE

- Public water supply systems
- Public wastewater return flow
- RIPDES discharges
- Aggregate uses estimated by town and basin:

  - Domestic, Agricultural, Commercial, and Industrial

NEWUDS Database

- Stores data found in Water Supply Management Plans
- Tool for Water Suppliers to organize and account for water transactions

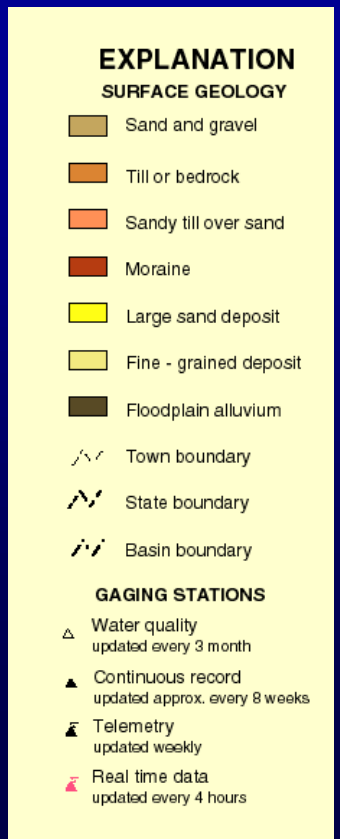
WATER AVAILABLILITY CALCULATIONS

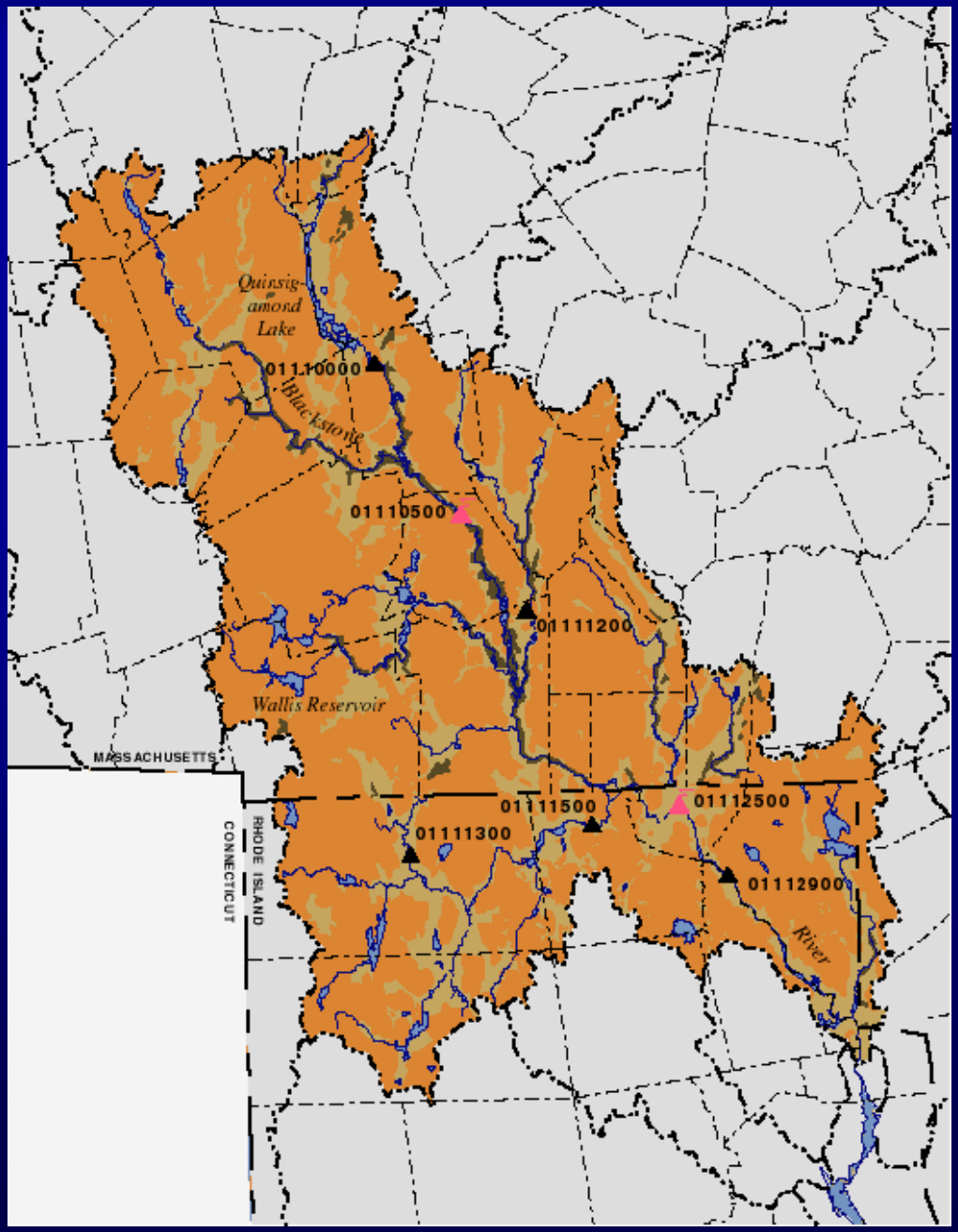
- Based on streamflow records; available water will be calculated using analytical techniques to estimate yield from stratified sand and gravel within the watershed.

- Volume of water available will be constrained for 2 different flow statistics so average streamflow depletion does not exceed Aquatic Base Flow (ABF) and the minimum average streamflow for 7 consecutive days in a 10 year period (7Q10 Flow).

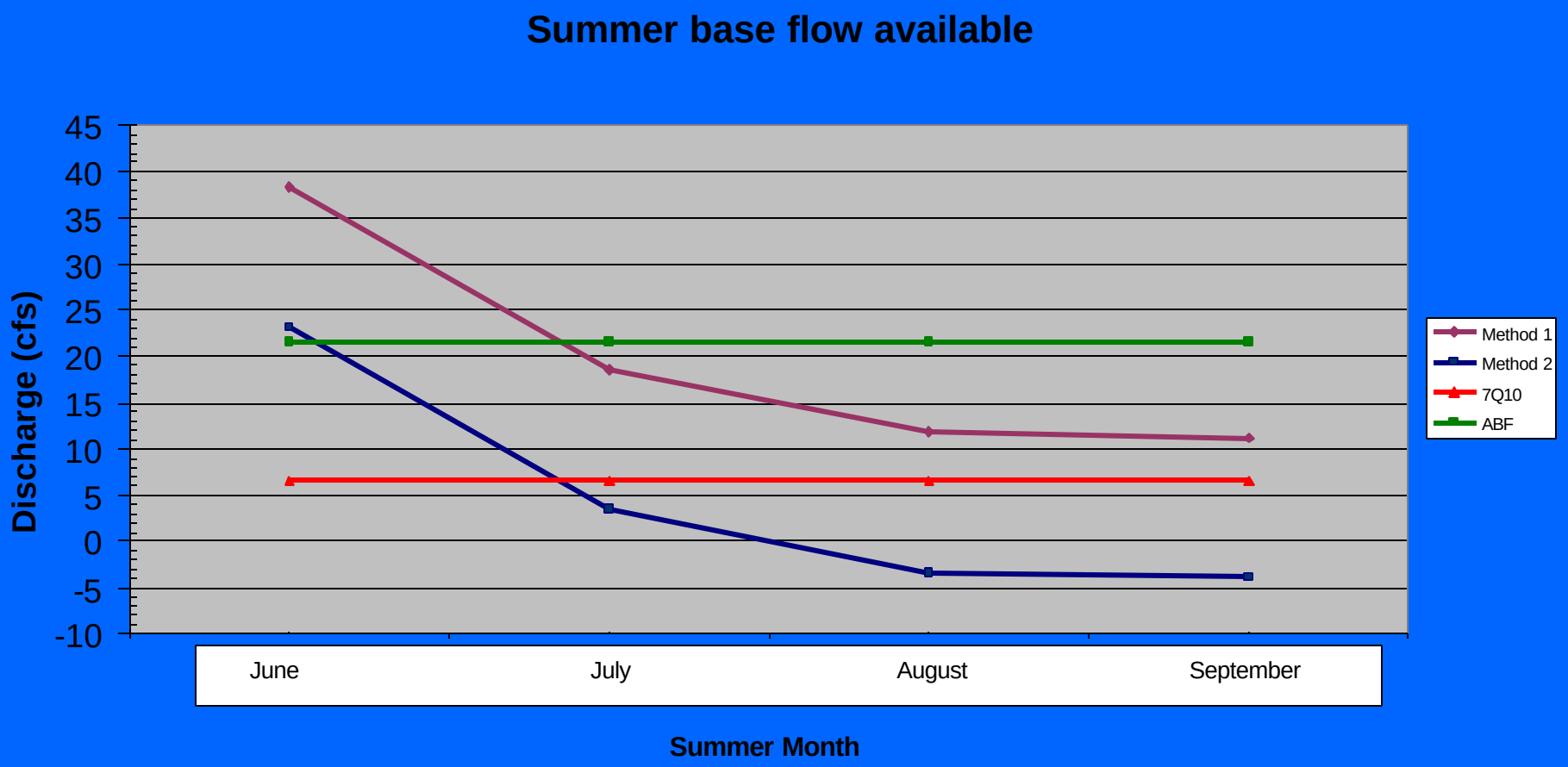
Blackstone River Basin

Drainage area= 472 mi^2
(139 mi^2 in RI)





Summer monthly flows, 7Q10, ABF

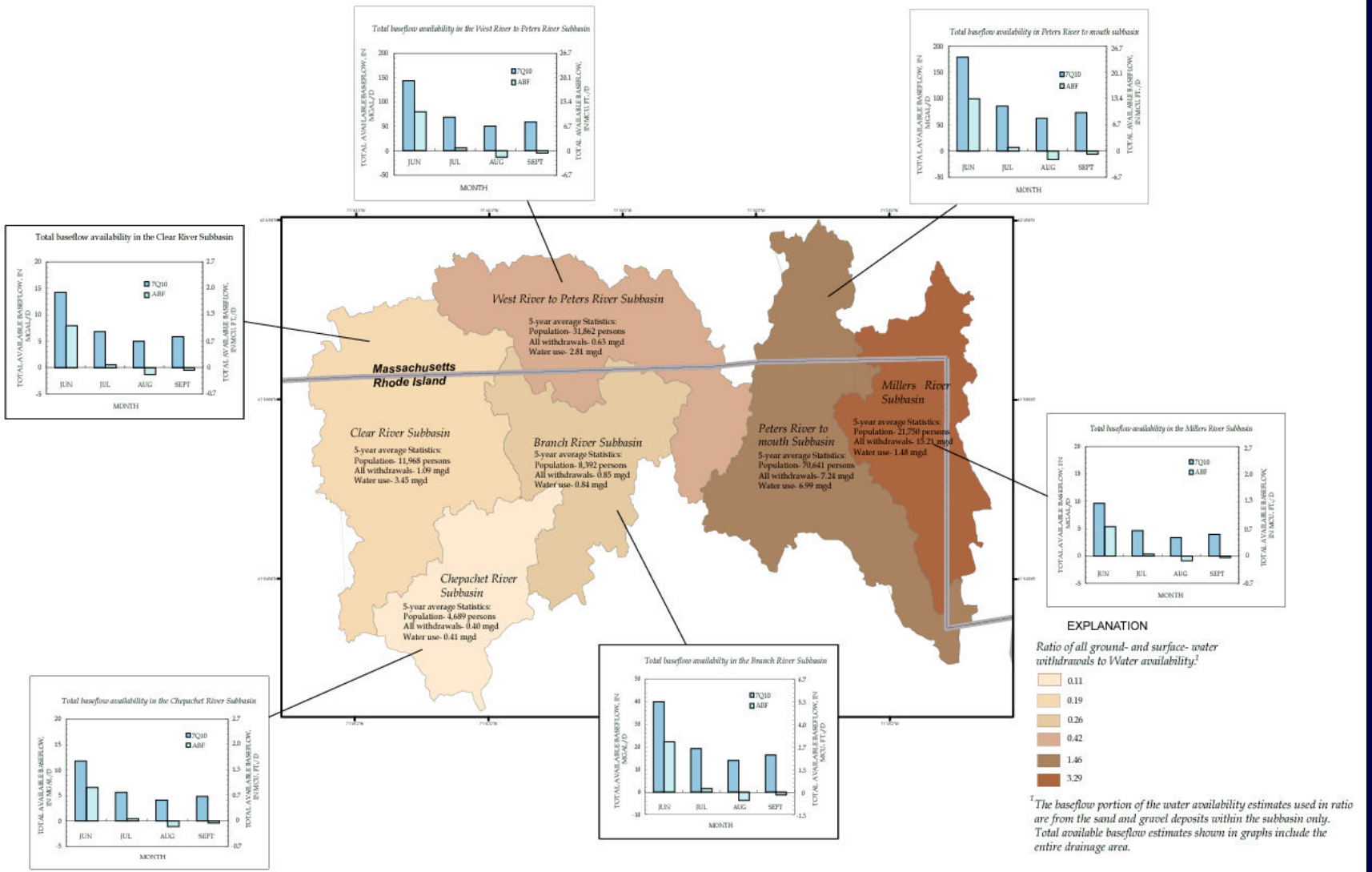


Ratio of Water Withdrawals to Water Availability

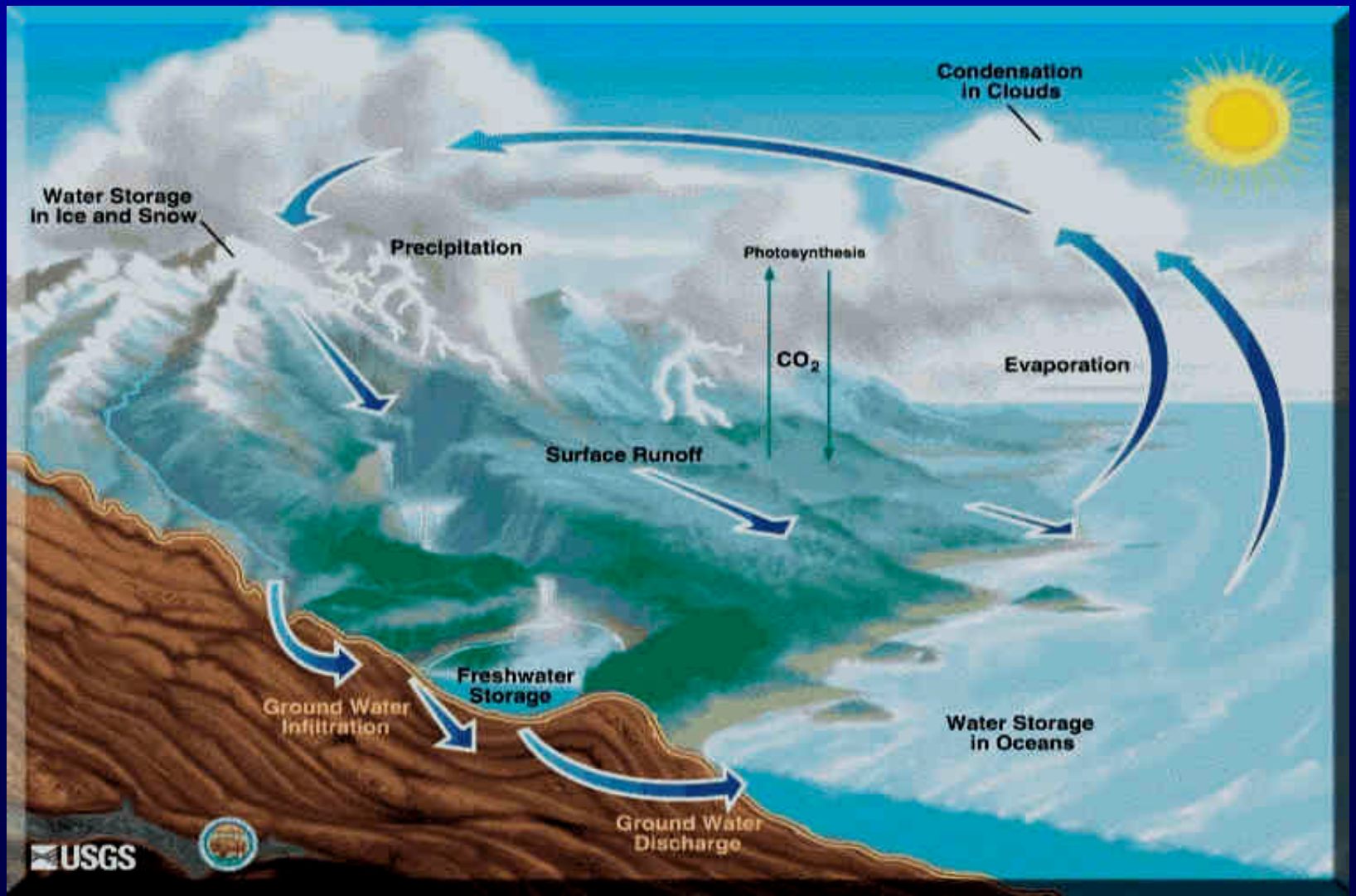
- Water withdrawals from basin
  - Ground water: wells
  - Surface water: reservoirs
- Water availability
  - Ground water: from sand and gravel deposits
  - Surface water: safe yield of reservoirs

Water withdrawals to water availability ratio in the Blackstone River Basin, Rhode Island

Figure __ Indication of subbasin stress based on the ratio of total withdrawals, 1995- 99, to estimated water availability, 1957- 99, during the month of August and total available baseflow available in June, July, August, and September for six subbasins within the Blackstone River Watershed.



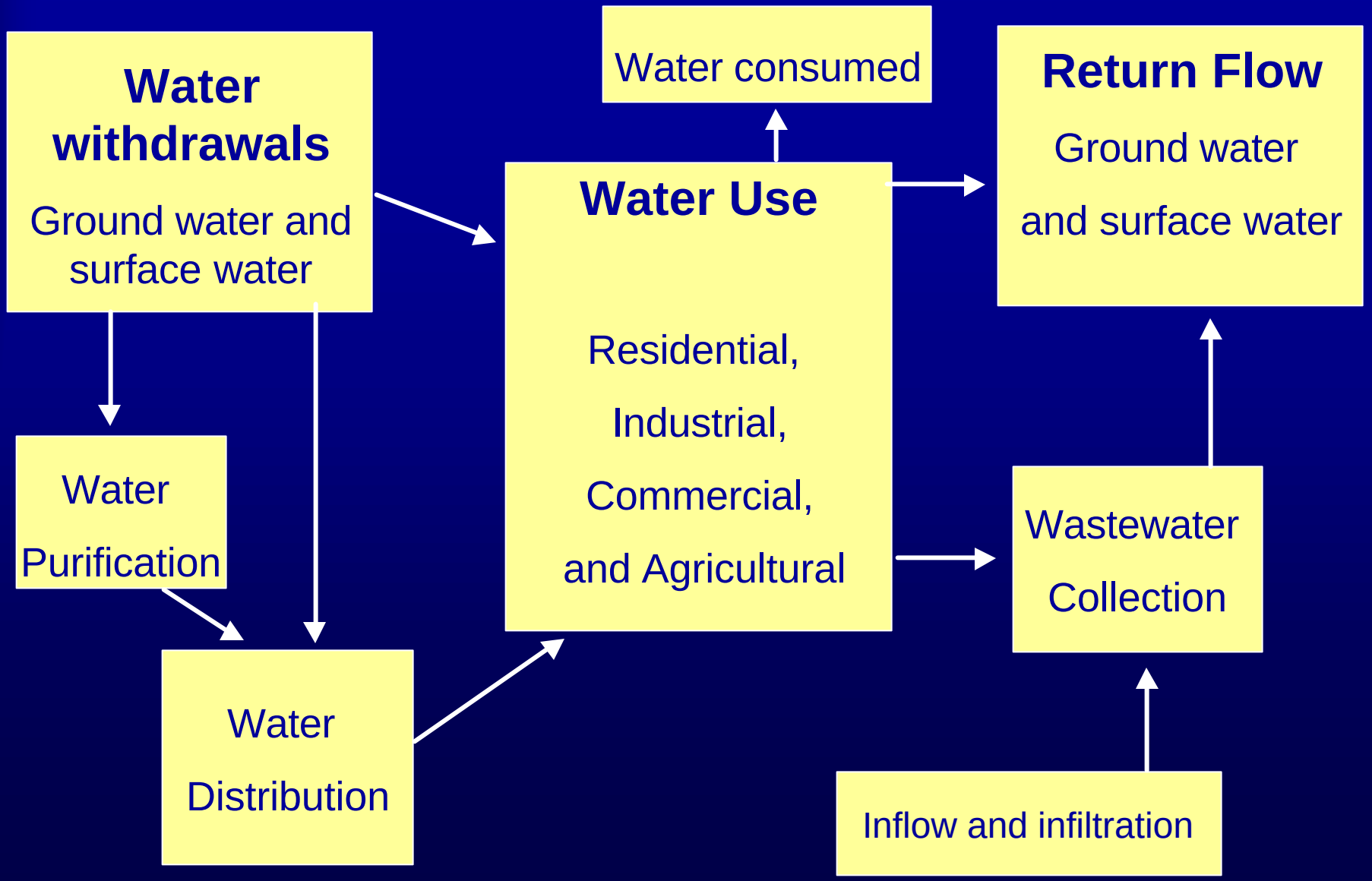
Water Cycle


Condensation in Clouds
Water Storage in Ice and Snow
Precipitation
Photosynthesis
CO_2
Evaporation
Surface Runoff
Freshwater Storage
Ground Water Infiltration
Water Storage in Oceans
Ground Water Discharge
USGS

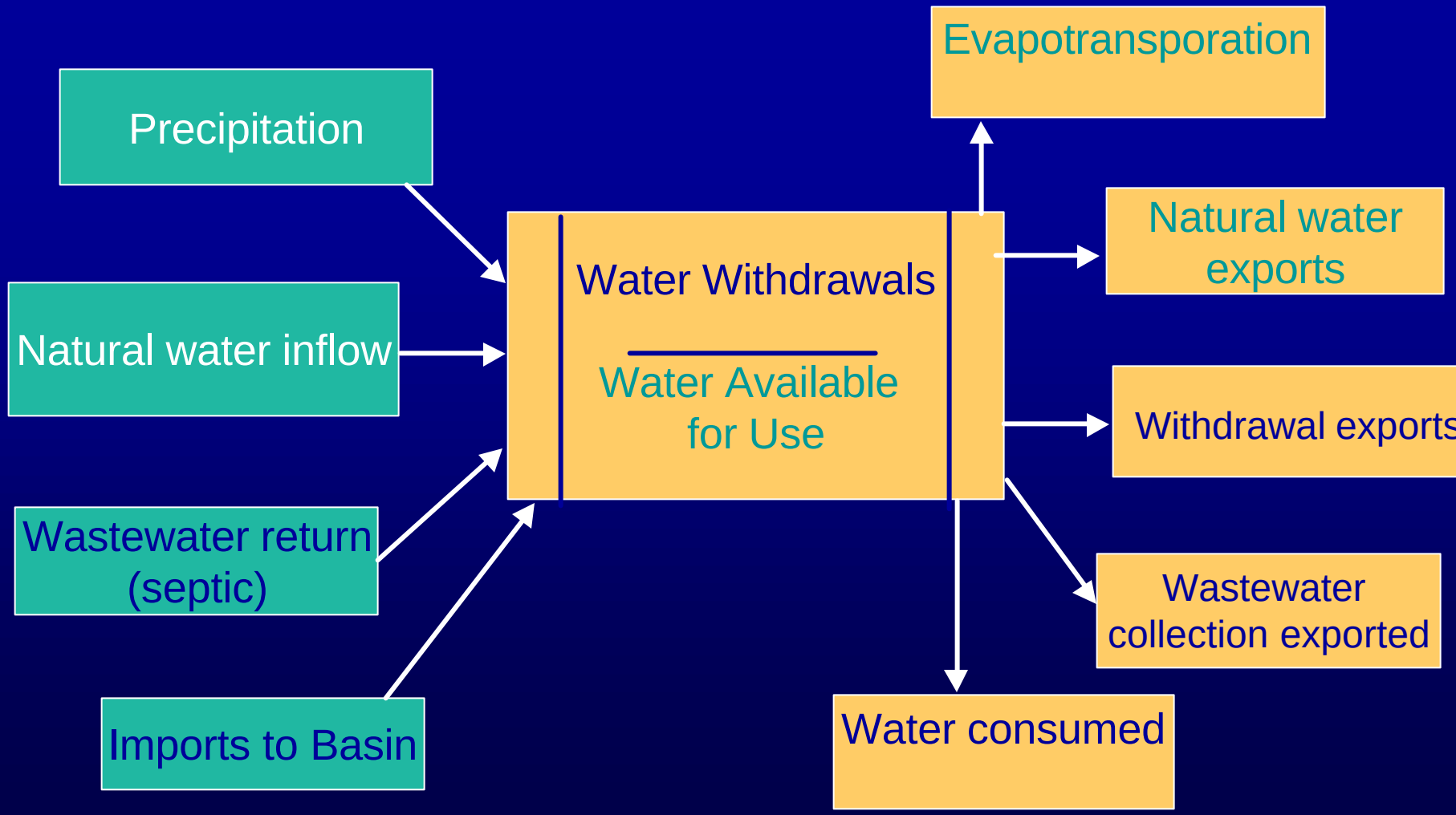
Basin Water Budget

- Inflow = outflow
- Precipitation = Evapotransporation + Consumptive Use + Outflow (discharge)

Water Use Cycle



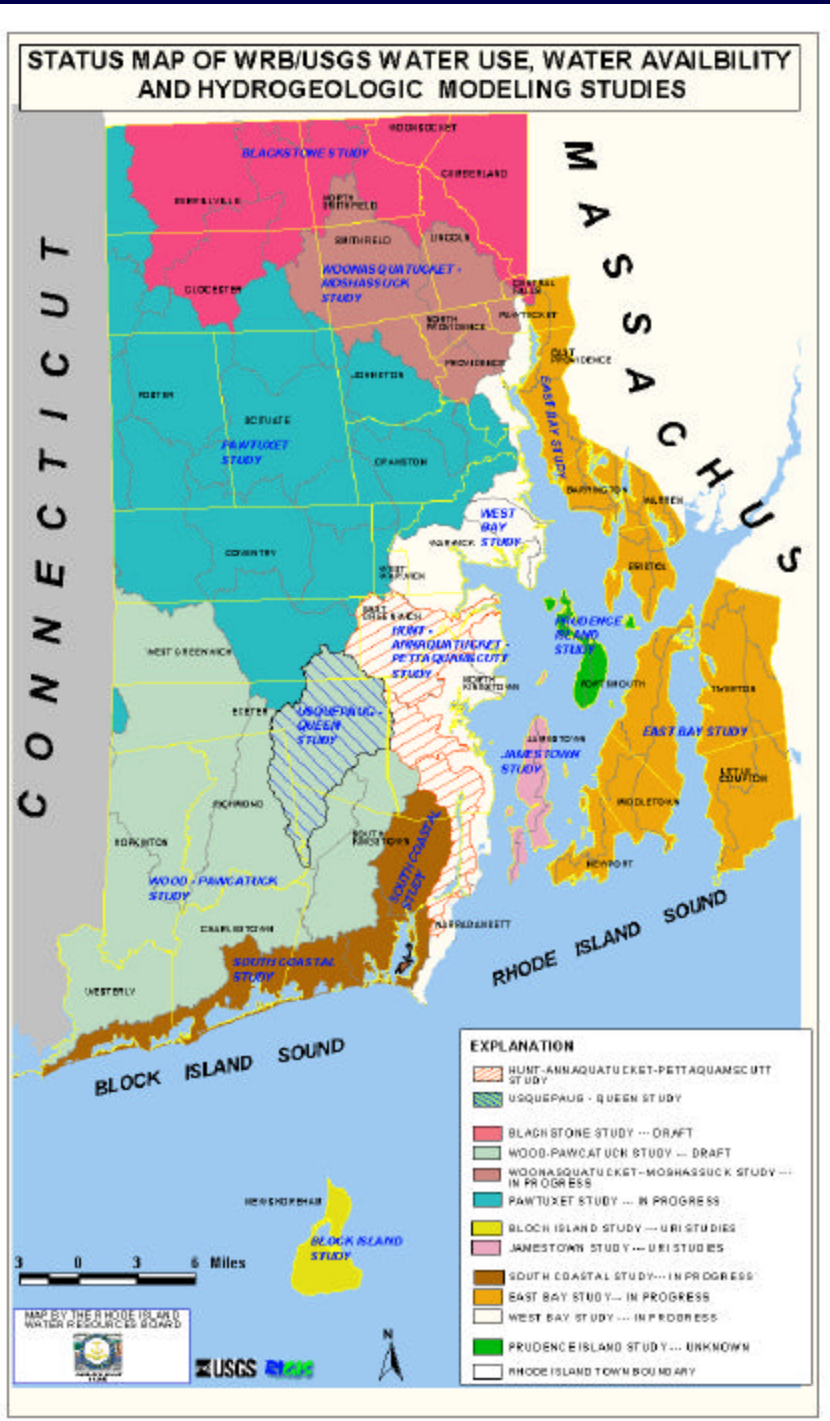
Water budget with water use complexity (inflow= use + outflow)



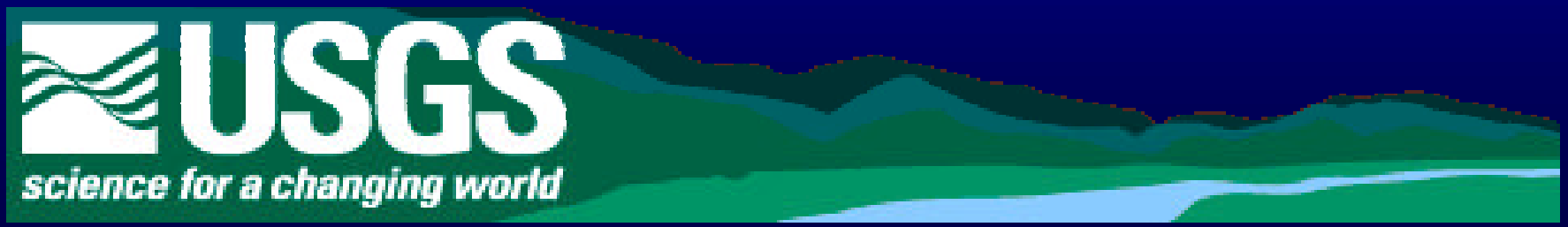
USGS
science for a changing world

Basin Projects in Rhode Island

State of Rhode Island
Water Resources Board



Ground-Water-Flow Modeling (HAP)



Benefits of the Ground-Water Model

- Provide a tool for management of groundwater
- Meeting current and future water needs by balancing:
  - (1) Water supply and
  - (2) Streamflow
- Can be linked with Optimization Model

What is an optimization model?

- Mathematical tool that tests user defined system constraints to the ground-water flow model

- “Optimization” will provide
  - Method of evaluating the location of new withdrawals
  - Operation of existing withdrawals to minimize impacts on hydrology
    - Minimum streamflow
    - Safe yields of wells (well fields)

OBJECTIVES

- Develop a ground-water-flow model to evaluate ground-water management alternatives
- Estimate contributing areas to supply wells
- Demonstrate the use of optimization techniques for evaluating ground-water management alternatives
- Minimize the impact of stream depletion during low-flow periods (July, August, and September)

RESULTS OF MODEL

- Increased understanding of the ground-water-flow system.
- Current streamflow depletion in the Hunt River could be decreased as much as 15 percent with modified well network (only 5 percent without).
- Increases in total ground-water withdrawals are possible with additional streamflow depletion in the Annaquatucket and Pettaquamscutt Rivers.
- Locations identified for modified well network (additional water supply).

Surface Water Watershed Model

Usquepaug-Queen River
Watershed Model

USGS
science for a changing world

Benefits of the Surface-Water Model

- Provide a tool for management of surface water and water quality
- Defines surface water runoff based on land use type

  - providing the ability to do build out analysis based on land use changes

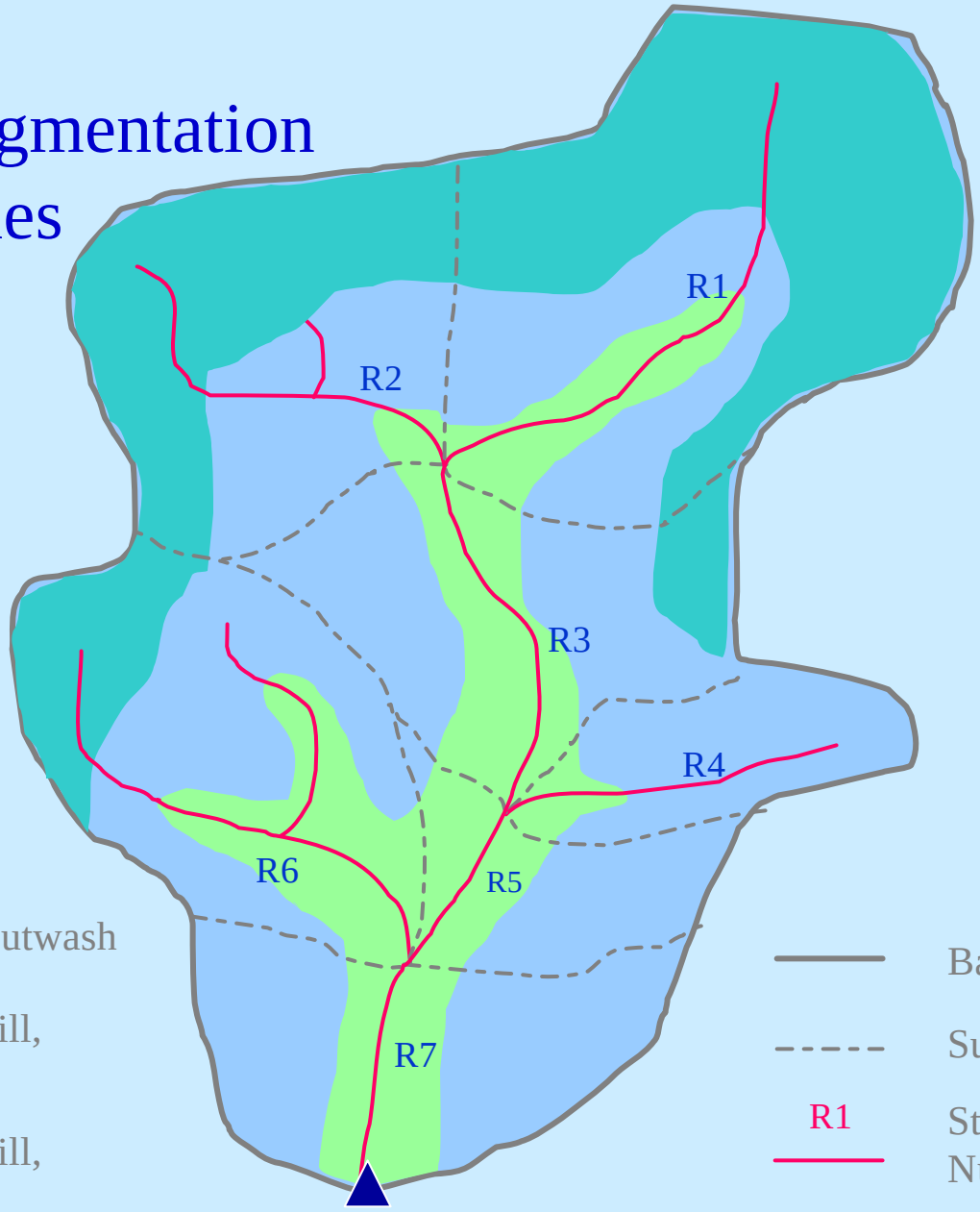
OBJECTIVES

- To evaluate the effects of water use and land use on streamflow in the Usquepaug-Queen River Basin using a watershed model

STEPS IN BUILDING THE MODEL

- Segment the stream network into reaches and nodes
- Segment the land surface into units of uniform hydrologic response
- Create input files for time series (streamflow, climatological, and water use) data and stream and land surface characteristics

Stream Segmentation and Reaches



Segment 1 - Outwash

Segment 2 - Till, Slope 0-5 %

Segment 3 - Till, Slope > 5 %

Basin **Boundary**

Sub-basin Boundary

R1

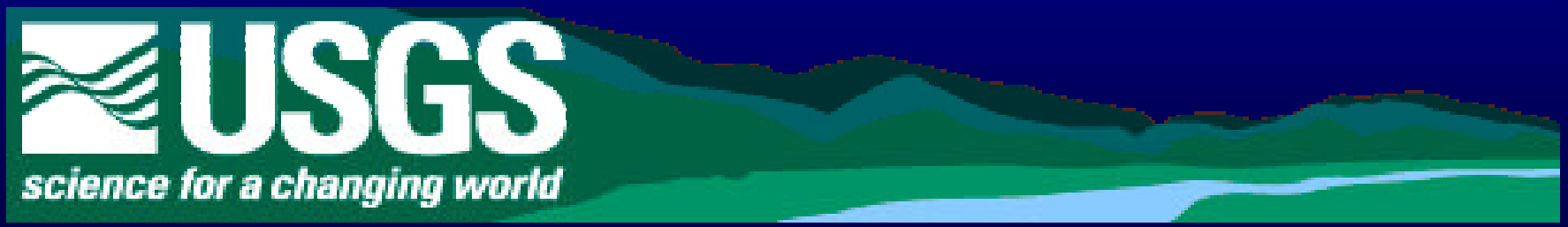
Stream Reach and Number

Stream Gage

POSSIBLE SCENARIOS TO BE EVALUATED WITH THE USQUEPAUG-QUEEN WATERSHED MODEL

- Streamflows with increased residential, commercial, industrial, and (or) recreational land use in the basin (i.e. restrictive recharge).
- Streamflows with current surface-water withdrawals converted to ground-water withdrawals.
- Streamflows with no water withdrawals under current and pre-development land uses.

Pawcatuck Watershed Model-Hydrologic System Model



Hydrologic System Model: Pawcatuck Watershed

Testing the link between the GW/SW models:

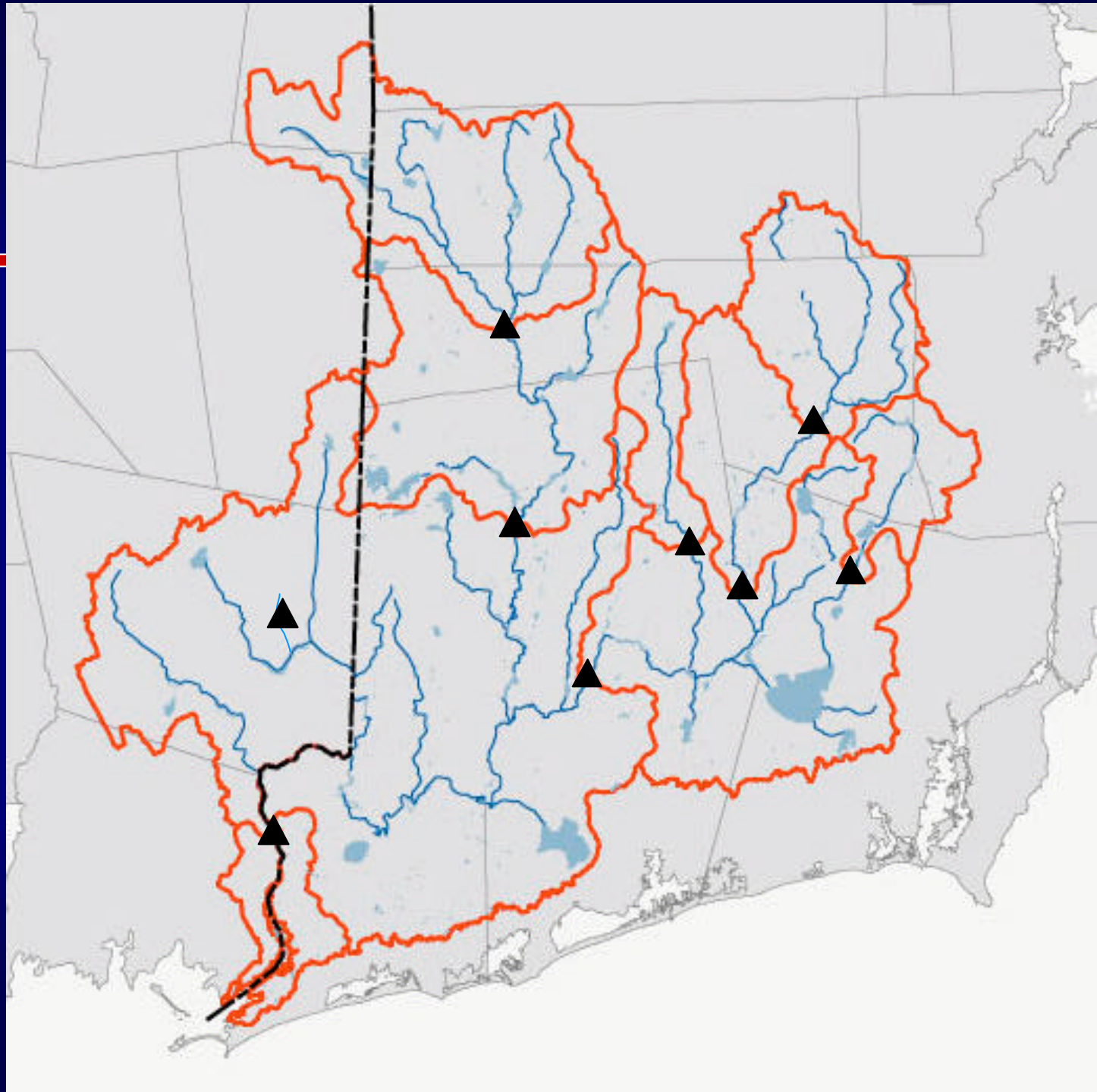
- First time in New England, ground water and surface water will be linked
  - Developed in Florida
- Usquepaug-Queen Basin will be used as test area

Objectives

- Link between surface water model (HSPF) and ground water model (MODFLOW)
- Gain better understanding of the hydrologic flow system

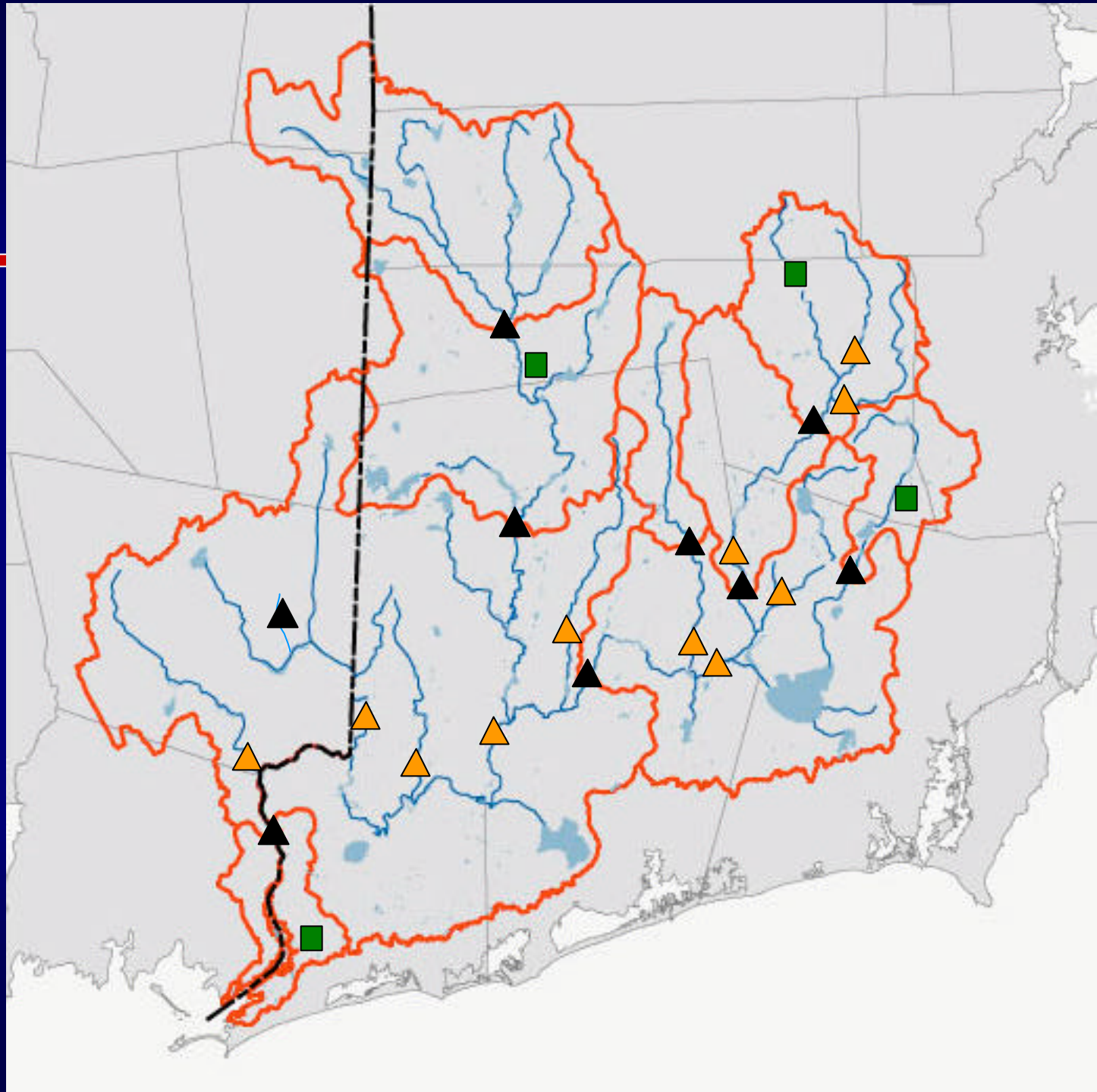
EXISTING SW GAGING STATIONS

△ Existing gaging station



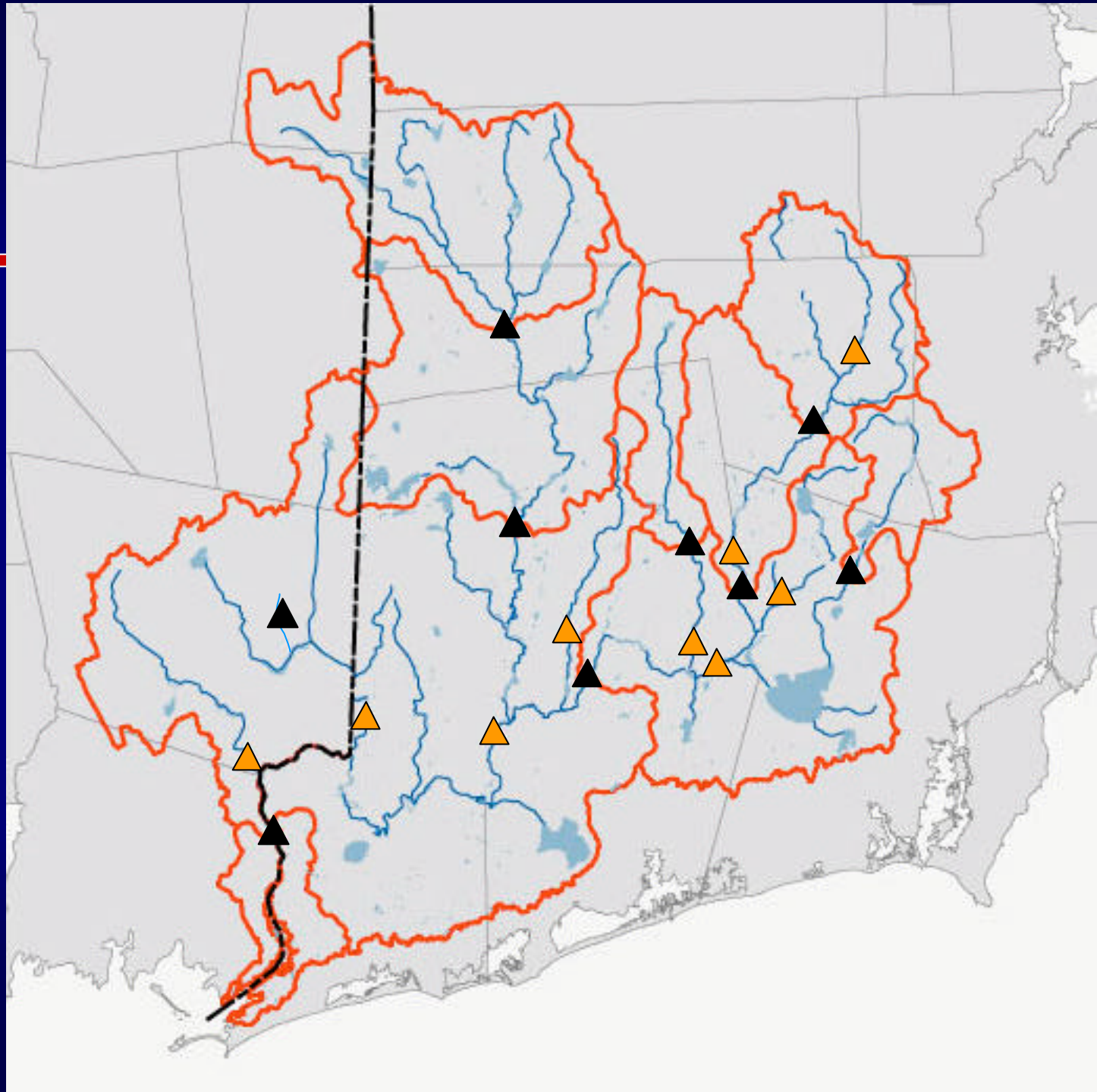
CLIMATE STATIONS

- Climate station
- Existing gaging station
- Proposed gaging station



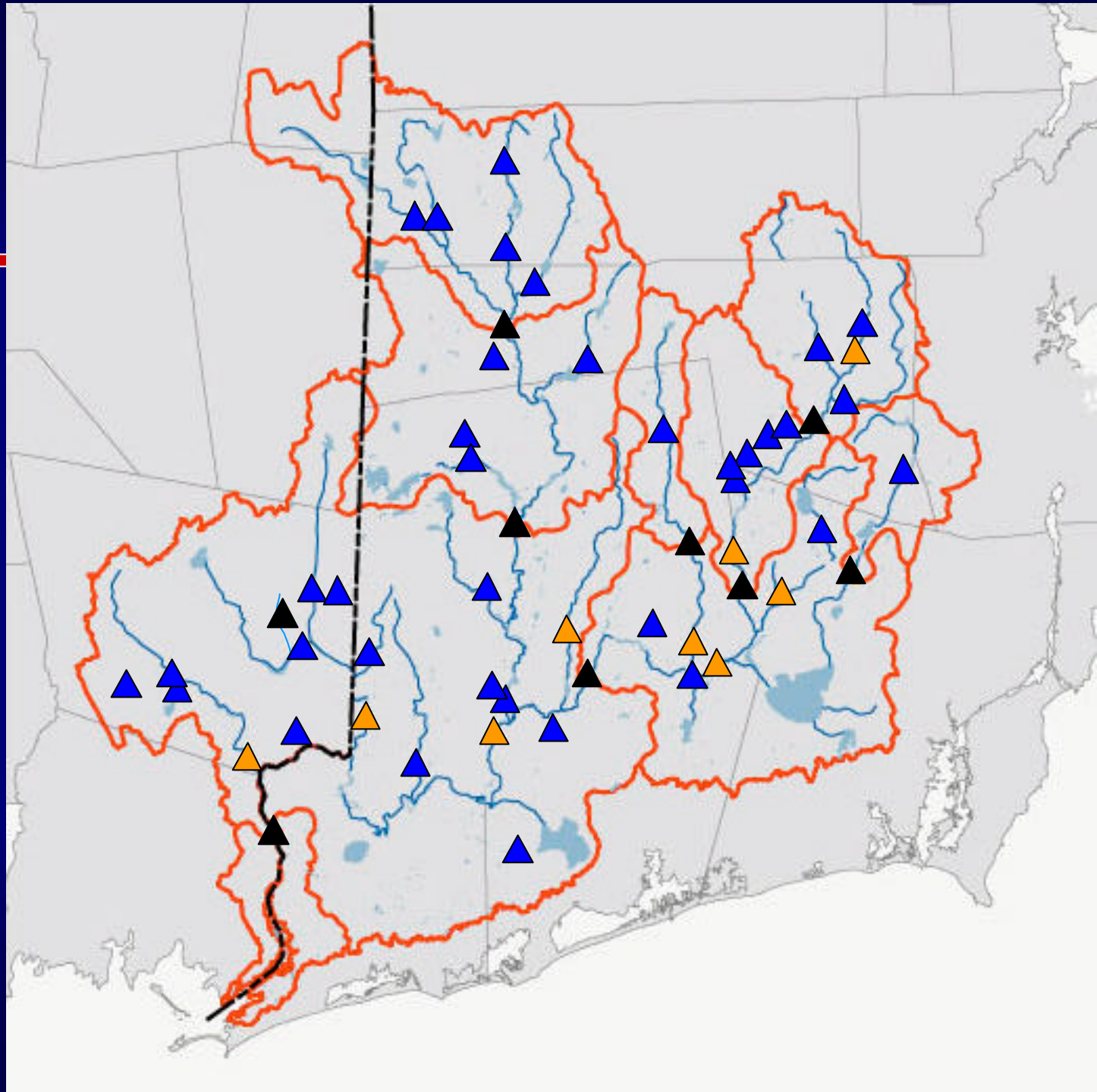
PROPOSED SW GAGING STATIONS

- ▲ Proposed gaging station
- △ Existing gaging station



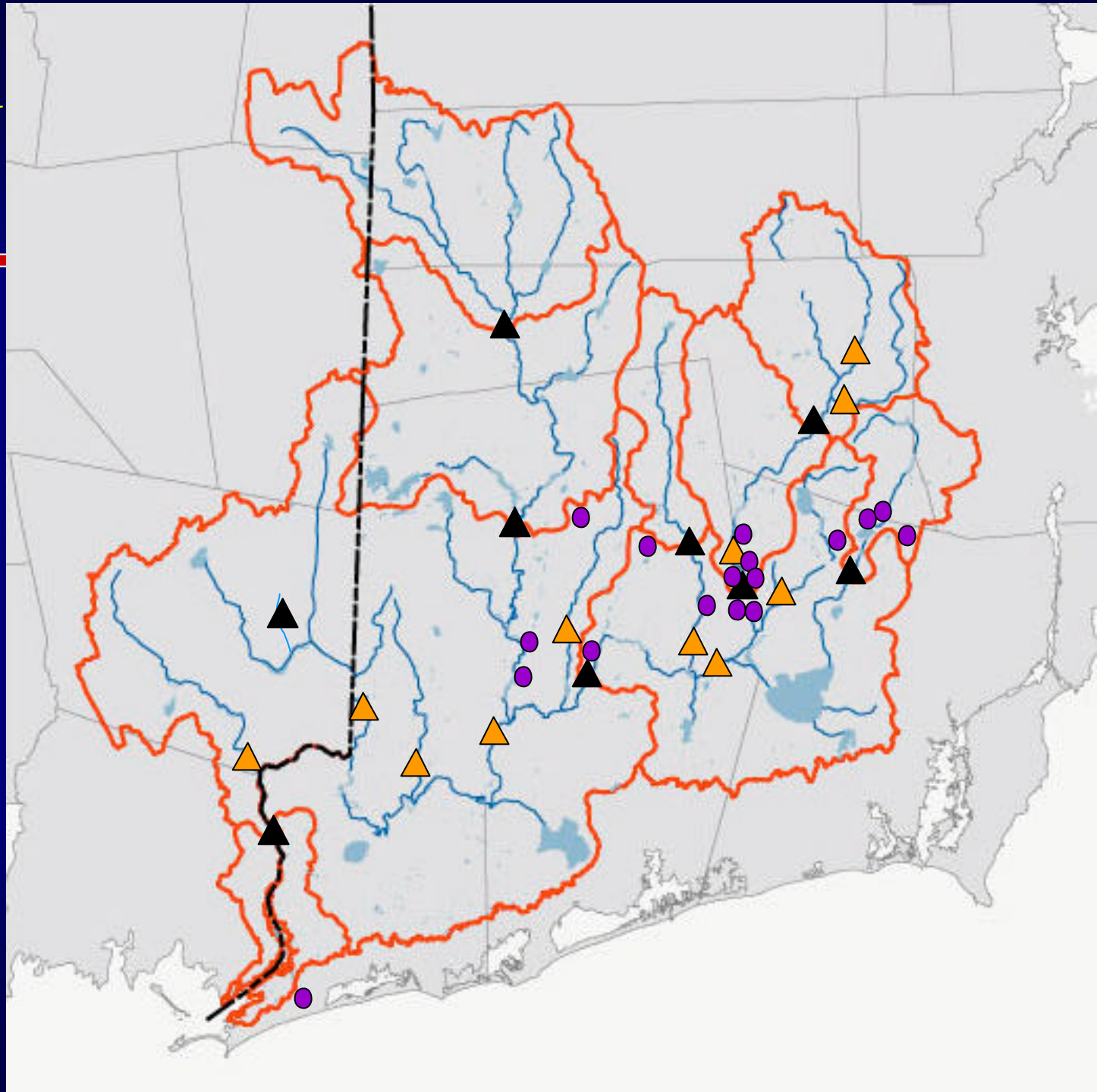
PARTIAL-RECORD STATIONS

- Partial-record station
- Existing gaging station
- Proposed gaging station



WU DATA COLLECTION SITES

- Water-withdrawal monitoring station
- △ Existing gaging station
- ▲ Proposed gaging station



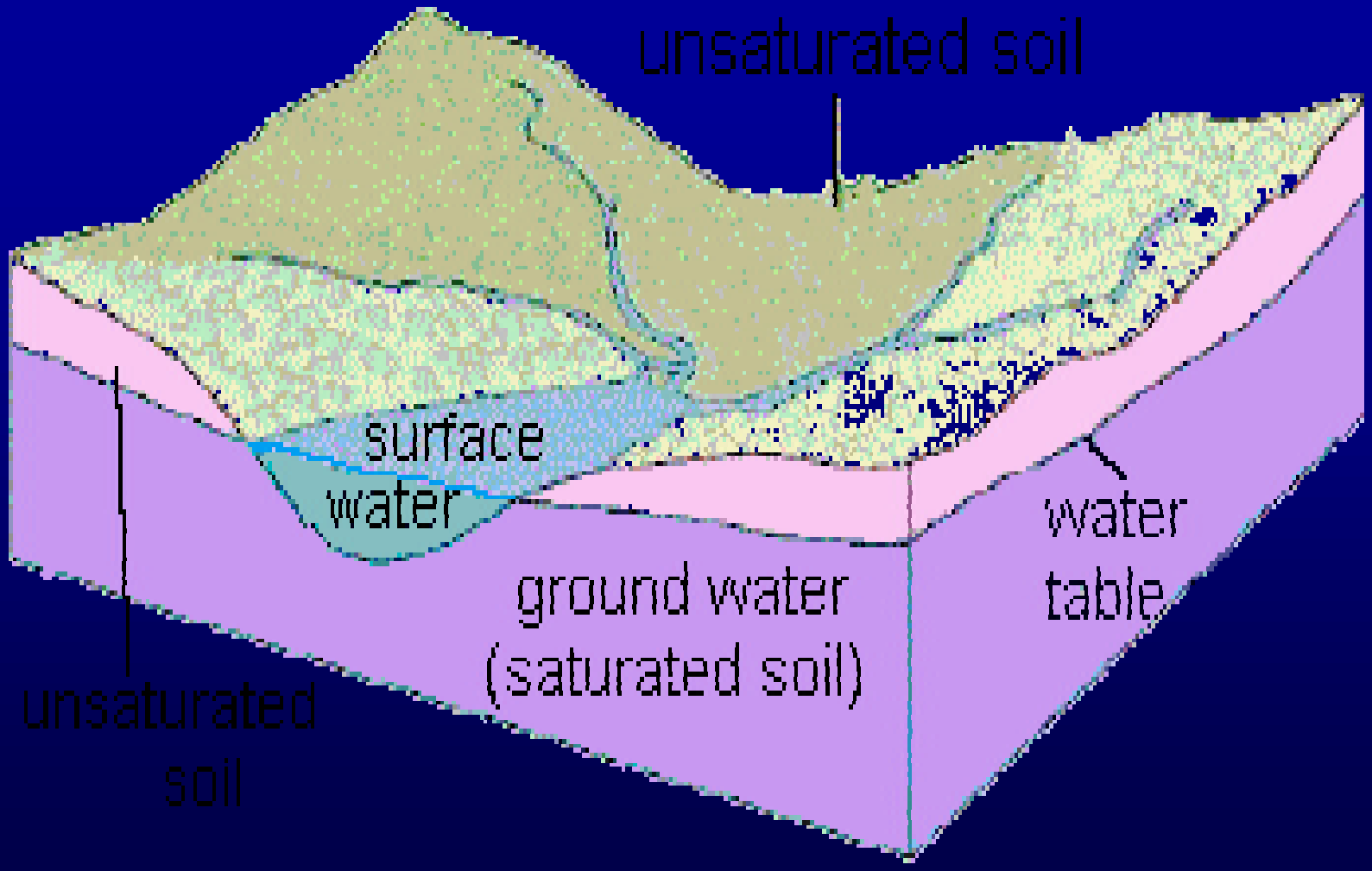
What is an optimization model?

- Mathematical tool that tests user defined system constraints to the ground-water flow model

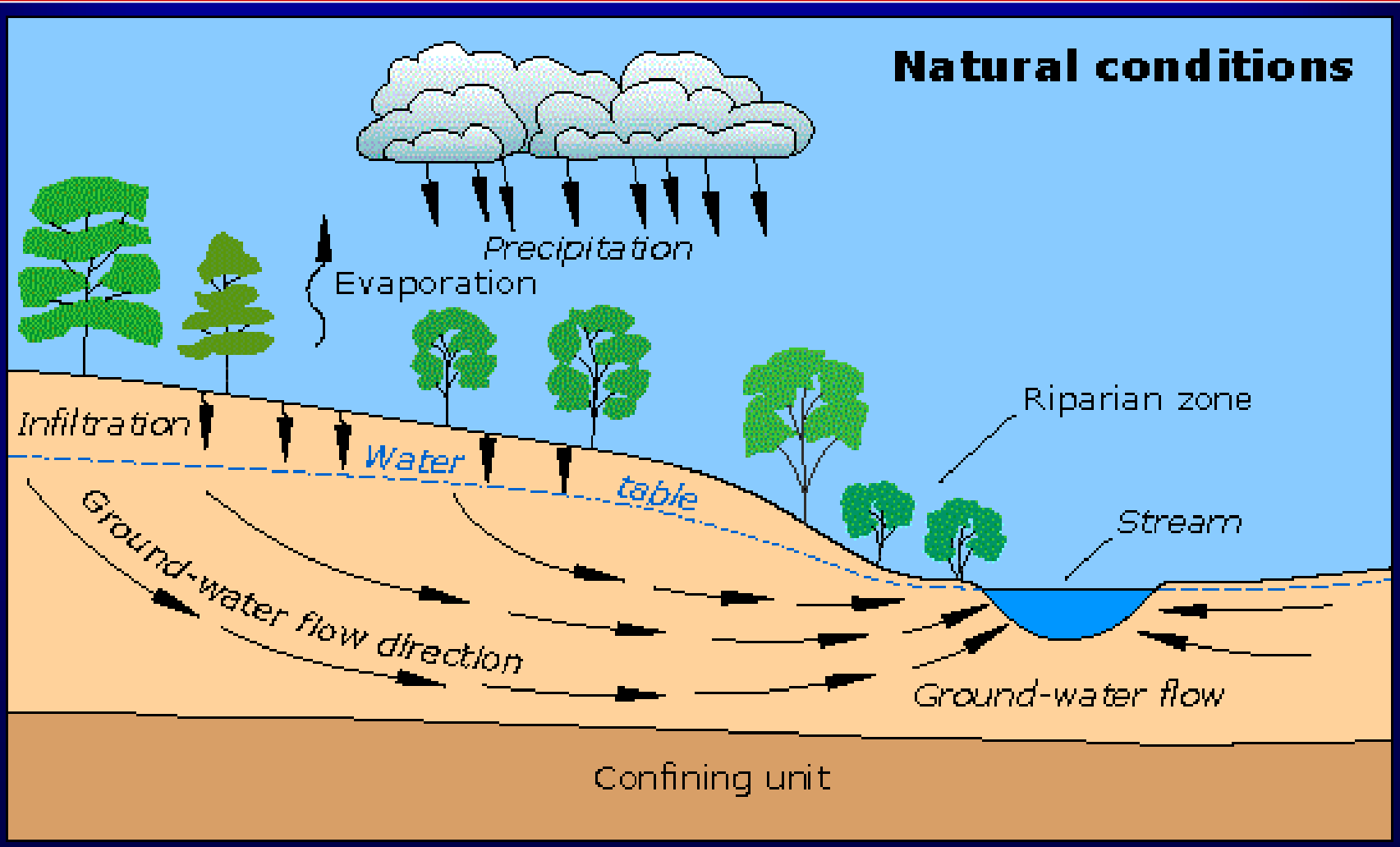
- “Optimization” will provide
  - Method of evaluating the location of new withdrawals
  - Operation of existing withdrawals to minimize impacts on hydrology
    - Minimum streamflow
    - Safe yields of wells (well fields)

Hydrology Concepts

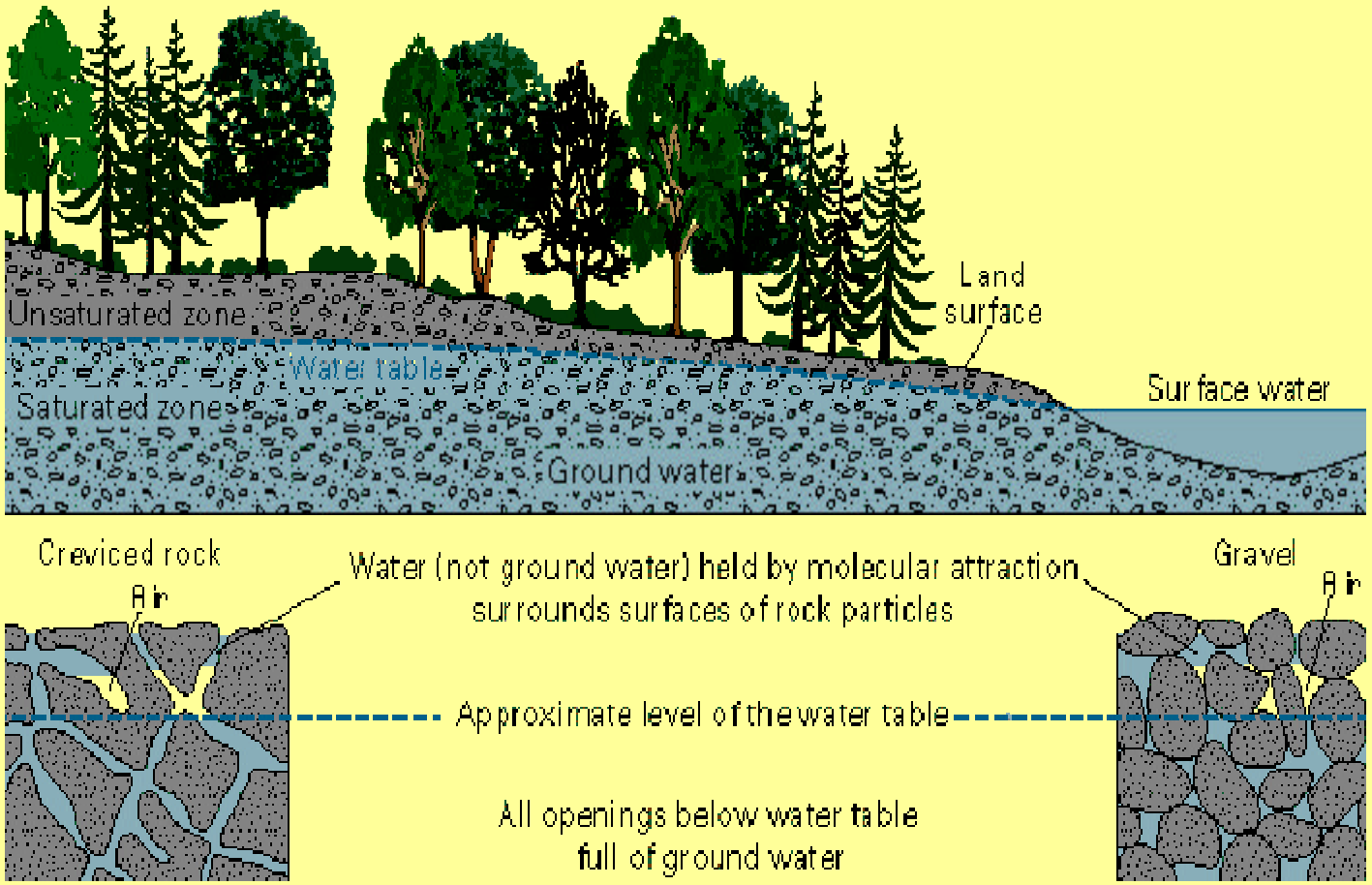
Ground Water and Surface Water- A Single Resource



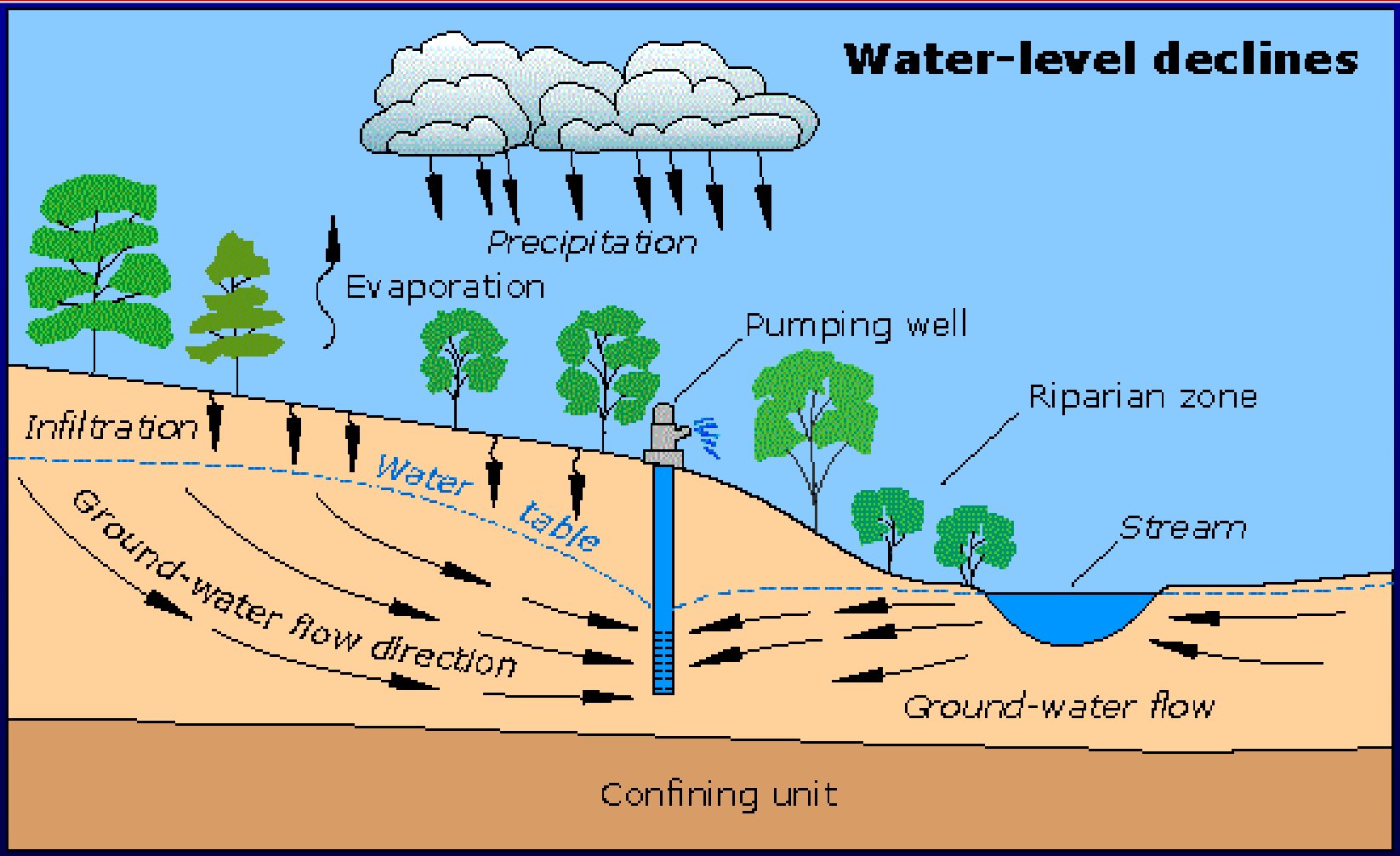
Ground-Water Flow



Ground-Water Flow Through Different Subsurface Media



Ground-Water Flow Under Withdrawal Stress

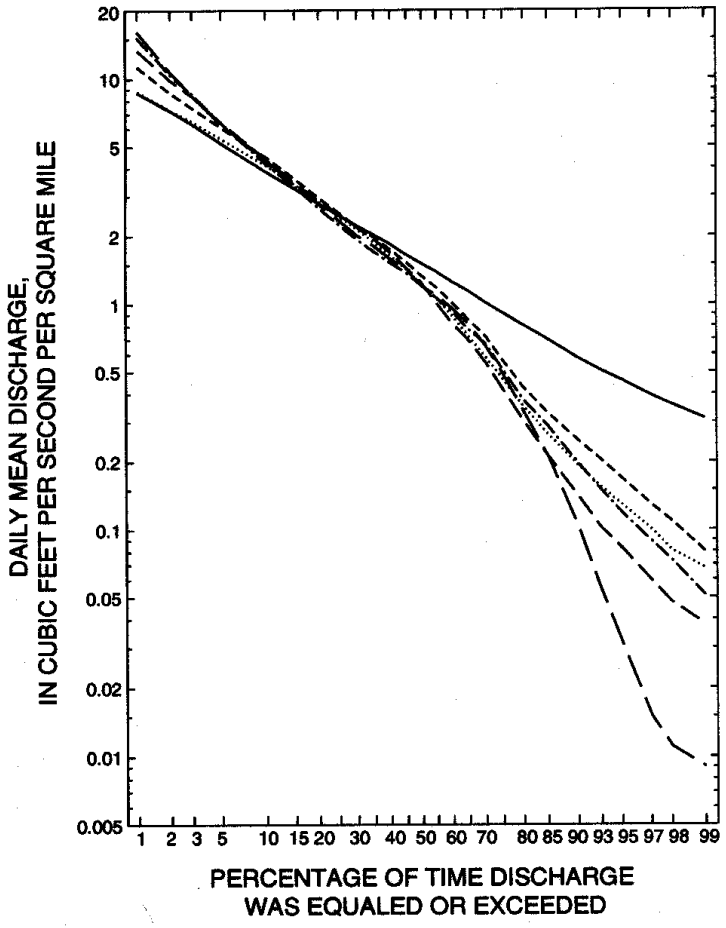


Fractured Bedrock

Flow Duration

- Flow Duration is a cumulative frequency curve that shows the percent of time specified discharges were equaled or exceeded during a given period.

Flow duration curves for selected surface water stations



OLD SWAMP RIVER NEAR SOUTH WEYMOUTH, MASSACHUSETTS (01105600)

INDIAN HEAD RIVER AT HANOVER, MASSACHUSETTS (01105730)

JONES RIVER AT KINGSTON, MASSACHUSETTS (01105870)

ADAMSVILLE BROOK AT ADAMSVILLE, RHODE ISLAND (01106000)

WADING RIVER NEAR NORTON, MASSACHUSETTS (01109000)

NIPMUC RIVER NEAR HARRISVILLE, RHODE ISLAND (01111300)

Flow Duration

- 10% Mean annual flow
  - 10% of the year flows are below this level
    - Approximately 36.5 days of the year
- 30% Mean annual flow
  - 30% of the year flows are below this level
    - Approximately 109.5 days of the year

Flow Duration

- 7-day, 10-year flow (7Q10)
  - 98-99% flow duration
  - 1-2% of the flow is less than 7Q10 (4-7 days)
- Aquatic base flow (ABF)
  - 89% flow duration
  - 11% of the flow is less than ABF (40 days)